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ABSTRACT

High schools throughout the United States are turning out graduates who are deficient in mathematics and science education. The field of education has come to be staffed by less competent teachers, as more qualified and more able individuals have been lured away to higher paying professions. The result of this has been the impairment of American ability to compete in the world market. Many high schools have deemphasized traditional core courses along with mathematics and the sciences. The National Education Association (NEA) has been a barrier to quality science and mathematics education in the public schools. The NEA has resisted efforts to institute standardized testing for teachers or assessment of teacher competence. The Department of Education has had deleterious effects on education, since it tends to promote equality of access to education at the expense of quality education. Finally, Congressional efforts have been to throw money at the problem rather than attack the root causes. Recommended solutions are: (1) redefined teacher certification requirements; (2) teacher accreditation through testing of general intelligence and knowledge in specific areas; (3) performance- and need-based salaries; (4) withdrawal of federal mandates; and (5) limited federal funding of education. (AOS)

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May 6, 1983

CLOSING THE MATH AND SCIENCE GAP

INTRODUCTION

American education is confronting a grave crisis. So declares the recent report by the President's Commission on Excellence in Education. Schools throughout the nation are turning out graduates woefully deficient in mathematics and science education. Over the past fifteen years the number of qualified secondary teachers of mathematics and science has fallen drastically. The prospects for training present education majors in these fields are dim, for education majors are increasingly drawn from the bottom quarter of college classes. These, regrettably, are least intellectually capable of grasping the demanding disciplines of mathematics and science.

Graduation requirements in many of this nation's public high schools have become embarrassingly lax; the traditional core curriculum has been gutted and replaced by courses of highly questionable academic merit. According to a National Institute of Education report, for example, 58.6 percent of American high school students in 1981 were enrolled in driver education, while only 37.3 percent were taking general science. Standardized test scores in verbal and mathematics apptitude have declined steadily over the past 19 years (in mathematics, they have declined 30 points). Not surprisingly, postsecondary institutions have had to institute remedial courses, which supplant rigorous course content, that prepares the graduate for gainful employment, responsible adulthood, and enlightened leadership. Naturally, the hard disciplines of physics, chemistry, engineering, and mathematics have suffered, with possible disastrous impact on the U.S. ability to compete on the world market.

Congress seems about to throw money at the problem, apparently oblivious to the fact that, as federal funding for education has increased over the past 15 years, academic performance has declined.

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And in their rush to expand the federal role, legislators seem to have forgotten that the Department of Education has presided over the virtual collapse of basic standards in public education.

The two leading bills now before Congress would provide funding primarily for training new mathematics and science teachers, retraining teachers of other disciplines in these subjects, and instituting in-service training programs. These congressional efforts are poorly targeted. They would spend money while ignoring the factors that threaten the education system as a whole, such as the exodus of bright women from the classroom and inadequate teacher salaries. Most important, the crisis in education can be traced to the centralization of education at the federal level and the abdication of control by the federal government to special interest groups. These groups have succeeded in mandating a false and destructive dogma, which aims for an unrealistic rigid equality at the expense of excellence, and dismantles an academically demanding curriculum. The most powerful interest group, the National Education Association (which lobbied hard for the Cabinet-level Department of Education), consistently and vehemently has resisted efforts to subject its membership to accountability or to hold students to standards.

In seeking competent mathematics and science teachers from a pool of increasingly academically incompetent education majors and in continuing to fund and enforce federal mandates that have crippled education, Congress is engaged in an exercise in futility. Taxpayer funds should not be given to those responsible for America's present educational predicament. Rather, Congress and the states should correct the basic faults of the education system. Certification requirements must be redefined to weed out incompetent, though supposedly "qualified," people, and to draw into education knowledgeable individuals from other fields. Teachers should be accredited by rigorous testing of general intelligence and knowledge of subject matter. Teacher salaries should be based upon performance. Finally, the federal government should recognize its sorry track record in education and withdraw from policymaking. Education is essentially a state and local matter and should be returned to them.

MANIFESTATIONS OF THE PROBLEM

The Shortage of Qualified Teachers

Although more than enough certified teachers are available in the U.S. (in 1977 approximately 160,000 applied for approximately 110,000 teaching positions),[1] a dearth of mathematics and science teachers persists. Between 1971 and 1980, the number of teachers nationwide prepared to teach secondary school mathematics

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[1] Survey of Recent College Graduates, U.S. Department of Education, National Center for Education Statistics.

declined 77 percent; those prepared to teach secondary school science declined 65 percent.[2] According to a 1982 report, 44 states indicated a shortage or critical shortage of chemistry and mathematics teachers; 45 indicated a shortage of physics teachers.[3] The result: mathematics and what are commonly referred to as the hard sciences (e.g., chemistry and physics) are seriously under-represented in the nation's public schools.

One reason for this shortage is that experienced teachers of mathematics and science are quitting. In 1980-81, 4 percent of them left for higher paying employment, primarily in business and industry--a rate five times the loss due to teacher retirement.[4] Many of the vacated math and science teaching positions are either being filled by teachers certified in non-science disciplines or are not being filled at all. In 1980, for example, 26 percent of the nation's teaching positions in mathematics were held by teachers not certified in the subject.[5]

Of greatest concern, however, is that public school teachers of rigorous subjects are selected from a group who, as college-bound high school seniors, were among the poorest students in mathematics and verbal skills as measured by Scholastic Aptitude Test (SAT) scores. Certification requirements compound the difficulty; some states do not even require that secondary teachers of mathematics study up to the level they may teach.[6]

Falling Graduation Requirements

Although 45 states have secondary school graduation requirements, eight require no units of mathematics and ten require no units of science. Only one-third of America's 16,000 school districts demand more than one year of mathematics or more than one year of science for a diploma. Fewer than one third of the high schools even teach calculus.[7] In many high schools, a credit in driver education is considered equivalent, for purposes of graduation, to a credit in physics or math.[8]

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2 Chris Pipho, "Differential Pay Schedules: A Solution to the Teacher Shortage?" Phi Delta Kappan, March 1983, p. 453.

3 National Convention in Precollege Education in Math and Science, National Science Foundation Fact Sheet, May 1982.

4 Pipho, op. cit., p. 453.

5 Ibid.

6 Lawrence P. Grayson, "Leadership or Stagnation?: A Role for Technology in Mathematics, Science and Engineering Education" (a National Institute of Education study), Engineering Education, February 1983, p. 363.

7 National Convocation in Precollege Education, op. cit.

8 Tom Wicker, "Asking Less, and Getting It," New York Times, March 25, 1983, p. A31.

A report by Clifford Adelman of the National Institute of Education prepared for the National Commission on Excellence, compares the percentages of students enrolled in certain courses from 1971 to 1981 with those of students enrolled in those same courses from 1964 to 1969. In 1969, the report showed, 96.9 percent of American secondary students were enrolled in English I; this had dropped to 76.5 percent by 1981. In 1969, 87.8 percent were taking U.S. government; in 1981, this had fallen to 51.1 percent. General science classes contained 61.1 percent of American students in 1969; in 1981, only 37.3 percent took such classes. Algebra I enrollments fell to 63.8 percent in 1981, from 75.5 percent in 1969. Conversely, enrollments in sociology jumped to 19.0 percent in 1981 from 6.9 percent in 1969, while student enrollments in driver education skyrocketed to 58.6 percent in 1981, from a mere 0.3 percent in 1969.

Poorly trained high school students translate into lowered standardized test scores. Since 1965, mathematics and verbal SAT scores have declined. Between 1965 and 1980 the scores on the mathematics section of the SAT fell from 496 to 466.[9]

Poorly prepared high school graduates adversely affect the academic rigor of the colleges they enter. Indeed, the number of remedial courses in four-year institutions of higher education increased 72 percent between 1975 and 1980. By 1980, one-fourth of all mathematics courses offered in two- and four-year institutions of higher learning were remedial.[10]

Is it any wonder that there has been a disturbing decline in the number of postsecondary students receiving degrees in the hard sciences, engineering, and mathematics? In 1950, 36 percent of all bachelor and first professional degrees were in science and engineering. In 1980, the proportion had fallen to just 29 percent. In 1965, a record 30 percent of all master's degrees were in science and engineering; by 1980, the figure was 18 percent. The share of doctoral degrees received in science and engineering fell from a high of over 60 percent during the years 1950 through 1969 to a low of 51 percent in 1980.

The net result of this general decline in the knowledge base has been poorly prepared graduates entering the work force. For the first time America's newest adults are less skilled than their parents (a syndrome known as "downward mobility"). Industry, which traditionally has depended and built upon the basic academic competencies of its new recruits, can no longer do so. To date, some 300 of the United States' largest companies have been compelled to offer remedial courses in basic mathematics and English for their entry-level workers.[11]

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9 National Convention in Precollege Education, op. cit.
10 Report by the National Commission on Excellence in Education, April 1983.
11 John Naisbitt, Megatrends (New York: Warner Brothers, 1982), p. 32.

The military, too, needs an increasing number of educated troops for their Specialized Skill Training, which equips officer and enlisted personnel with the skills and information to perform special jobs such as medical specialist, electronic engineer, propulsion engineer, field radio operator, aircraft maintenance specialist, and aerospace ground equipment mechanic. The Reagan Administration's military program increases the demand for science trained workers in the companies building the new, sophisticated weapons systems.

The average citizen today must make political decisions and judgments about scientific concerns as diverse as toxic waste disposal, genetic engineering, robotics, and nuclear power. Without a fundamental knowledge of the disciplines which undergird these topics, Americans have no base from which to weigh and measure conflicting information.

THE ROOTS OF THE PROBLEM

Women Leaving Teaching

Education imparts and replenishes the culture of the society it serves. The quality of that culture depends in great measure upon the quality of its educators. In the United States, these educators historically have been among the finest and brightest women. Today, however, bright women have left education to pursue professions traditionally open mainly to men. By 1990, for example, it is predicted that the number of women earning bachelor degrees in business will be eight times greater than the number earning such degrees in the 1960s.

Salary

A key disincentive for attracting and retaining quality teachers is salary. Teacher salaries are now the lowest of any profession requiring a college education. Using constant 1980-81 dollars as a measure, the annual salary of classroom teachers fell from a high of $20,533 in 1973 down to almost $17,000 in the 1980s, a 15 percent decline.[12] This is a particular problem in the case of mathematics and science, where science graduates choosing business as a career can expect salaries well above their colleagues in the teaching profession.

Poor Quality of Teacher Colleges

Many of those entering teaching today do so because they either cannot or will not succeed in more demanding careers. This, in turn, depresses the quality of teacher colleges and

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12 Nancy Dearman and V.W. Plisko, eds., The Condition of Education 1982, (Washington, D.C.: National Center for Education Statistics, 1982) p. 103.

education departments. Lyn Gubser, former executive director of the National Council for Accreditation of Teacher Education (NCATE), complains that the enforcement of the council's standards has relaxed over the past several years. In the mid 1970s, he reports, fewer than 5 percent of the institutions reviewed by NACTE were denied accreditation in one or more programs. For the next few years, however, more rigorous accreditation standards were applied, and by 1978, 25 percent of the institutions reviewed had programs turned down. By 1982, only 5 percent of the institutions reviewed were denied accreditation in one or more programs. This decline apparently was attributable to the failure of NCATE to hold programs to the more rigid standards.[13] A NCATE committee, moreover, recently proposed that the council eliminate its most important requirement: that institutions of teacher education evaluate their graduates.

Teacher colleges and education departments stress education and methods courses rather than those with substantive discipline content. In the case of science, such emphasis could produce science teachers who may know something about teaching methods but who could know little about science. Good scientists and mathematicians who are attracted to education often find that the route they are required to travel in order to teach screens out the very competencies needed to do it well. The present process of acquiring a teaching certificate effectively removes education from consideration by many--probably most--of the brightest and the best.

The National Education Association

A serious barrier to quality science and mathematics education in the public schools is the National Education Association (NEA). A union representing nearly four-fifths (or 1.6 million) of the nation's teachers, NEA is one of the most powerful political lobbies. It lobbies, however, only rarely in the best interests of education, but primarily for the immediate interests of its own membership: for teachers' economic gain and job security.

As the teacher population is increasingly drawn from the bottom quarter of college classes--the population least capable of handling the rigorous disciplines of math and science--the NEA has fought to eliminate or weaken all measures that would question the performance of their membership. For example, the NEA vehemently opposes standardized testing--the best researched and most accurate measure of academic performance available--arguing that it "fosters inequality." The union also opposes assessments of teacher competence, either before certification or at any time during a teacher's tenure. Its opposition is effective.

NEA's stated goal is to control all teacher training and employment, arguing "the profession must govern itself," as do

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13 "A Conversation with Lyn Gubser," Education Week, March 23, 1093, pp. 7, 17.

other professions. It has also succeeded in enforcing compulsory union membership (with dues set at several hundred dollars a year per person) in many jurisdictions.[14]

What the NEA has chosen to overlook, however, is that other professions are subject to accountability. If a lawyer loses too many cases, he soon has no clientele. The education profession, on the other hand, has no such checks. Tenure is automatic for any teacher who has taught more than three years. An incompetent teacher, therefore, in most cases reigns unchecked. While other professions have stiff standardized entry tests, entry into education poses few barriers. Other professions attract individuals from the higher college strata; education attracts those from the lowest. In addition, the NEA consistently and vigorously has opposed differential pay rates to provide higher rates of pay in disciplines where there is a shortage. If schools are to pay science teachers enough to attract high quality recruits, the union also would have them pay the same rates for incompetents and for teachers in fields where there is already a surplus.

Federal Actions

The most damaging blows to science and mathematics education, have been from Washington. Federal actions have dismantled an academically demanding curriculm and provided the NEA with a Cabinet-level Department of Education. For the past twenty years, federal mandates have favored the disadvantaged pupils at the expense of those who have the highest potential to contribute positively to society. Less able students have received almost exclusive attention and massive federal funding. While there have been test score gains at the lower end of the scale, they have been more than offset by declines at the upper end of the scale. Further confirmation of the negative impact of federal mandates comes from the National Assessment of Educational Progress. This organization recently issued a report on the reading, science, and mathematics performance of American youth during the 1970s (see Chart I).

Chart I

National Mean Percentages of Changes in Performance in Reading, Science, and Mathematics, Within Lowest and Highest Achievement Classes for 9-, 13- and 17-Year-Olds for Two Assessments

	Age 9		Age 13		Age 17	
	Lowest	Highest	Lowest	Highest	Lowest	Highest
Reading	5.0%*	1.4%	1.4%*	0.3%	-1.0%	-0.4%
Science	1.0	-2.5*	1.5*	-2.5*	0.6	-3.9*
Mathematics	1.1	-3.0*	1.2	-3.4*	-1.2	-4.3*

* = Significant change in performance between assessments.

Source: "Reading Science and Mathematics Trends: A Closer Look," National Assessment of Educational Progress, December 1982.

[14] Chester Finn, "Teacher Politics," Commentary, February 1983, p. 12.

As the chart indicates, although the lowest achievers did improve, this was not nearly enough to offset the decline among the highest groups, especially in mathematics and science.

A key reason for this erosion of achievement standards is that the federal government has dismantled an academically demanding curriculm by catering to the demands of special interest groups, such as the disadvantaged, racial minorities, the handicapped, women, and non-English-speaking students. The concerns of each special group have replaced a generalized concern for the welfare and advancement of the whole. All special concerns are portrayed as having equal claims, as deserving equal consideration and equal fulfillment for lack of an objective standard by which to judge them. Indeed, any attempt to judge between them brings the criticism of discrimination. Yet, the mark of a civilized body politic is the ability to weigh competing claims and to order them on the basis of their merits.

The curricular changes which have been mandated by the federal government have infused education with a distorted and dangerous perception of the parts at the expense of the whole.

CONGRESSIONAL EFFORTS TO REMEDY THE PROBLEM

Efforts are underway in Congress to remedy the deleterious effects of the long-term neglect of mathematics and science in the nation's public school systems. One measure (H.R. 1310), introduced by Congressman Carl D. Perkins (D-Ken.), passed the House in March 1983. In the Senate, S. 530, whose chief sponsors are Robert T. Stafford (R-Vt.) and Claiborne Pell (D-R.I.), has just been endorsed by the Senate Arts, Education and Humanities Subcommittee of the Labor and Human Resources Committee. Both measures call for the usual federal solution of throwing money ($425 million and $400 million, respectively) at the problem rather than addressing the need to reform the education system itself.

H.R. 1310 places about half of its $425 million in the hands of the Department of Education. The Department is to parcel out these funds to the states according to a formula based on population and poverty statistics. The states, in turn, are to pass most of the money to local education agencies. These must use the funds to rectify deficiencies in mathematics and science at the elementary and secondary levels through such activities as in-service training for teachers, the updating of instructional programs, and the establishment of partnerships with outside organizations, such as institutions of higher education and business and industry. These partnerships are meant to take the form of in-servive training programs for math and science teachers, the lending or leasing of equipment to upgrade the school's instructional hardware, visiting lecturers from the private sector (under the supervision of a certified teacher), on-site instruction at the private sector location, and summer jobs in business and industry for classroom teachers.

At the postsecondary level, the federal government is called upon to fund a National Teaching Scholarship program to upgrade the skills of teachers currently certified in these disciplines and to encourage college students to choose teaching careers in them. H.R. 1310 stipulates that the pool of selected candidates must include "individuals who are unrepresented or underrepresented in the respective disciplines," such as women, racial and ethnic minorities, and the handicapped. In addition, funding for summer institutes to upgrade the knowledge base of already certified teachers and of their supervisors is provided.

The remaining portion of the $425 million is to be administered by the National Science Foundation to improve the quality of science and engineering faculty, instructional equipment, and college courses.

S. 530 is similar to H.R. 1310. Under the administration of the Department of Education, 90 percent of the designated $400 million is to be allocated to the states according to a formula based on population. Sixty-five percent of the state money is targeted for math, science, computer, and foreign language programs in elementary and secondary schools; 35 percent is targeted for teacher training, teacher retraining, and in-service training programs at colleges and universities. An amendment to S. 530 reserves some small percentage of state funds for exemplary programs to aid underrepresented populations, including minorities and women as well as the gifted and talented. Additional funds for programs administered by the National Science Foundation are expected to be added to this measure by the full Labor and Human Resources Committee.

The Administration is still cool to these measures, but has supported two bills: S. 706 and H.R. 1324, introduced by Senator Orrin Hatch (R-Utah) and Congressman John N. Erlenborn (D-Illinois), respectively. Unlike H.R. 1310 and S. 530, the Administration backed measures allocate comparatively limited dollars ($50 million) to train those individuals who could within one year become qualified to teach mathematics and science at the secondary school level. The Administration backed measures stress the inclusion of private schools in all transactions and add the significant statement: "Nothing in this Act shall be construed to require a scholarship recipient to become certified under state law." These bills, however, appear to have little or no prospect of enactment.

While Congress is clearly aware that the country faces an acute problem in science and mathematics education, its attempts to meet the crisis once again fail to address the underlying causes. Congress is seeking to spend taxpayers' money to counter the obvious and catastrophic symptoms while continuing to fund and enforce the equally obvious causes. The inevitable result will be the establishment of a huge new bureaucracy to absorb the funding while further obscuring the real issue.

Any in-service training attempts to upgrade the skills of the youngest generation of teachers probably is a waste of time, energy, and resources. These teachers are the product of the weakened curriculum of the past twenty years and have been drawn increasingly from the bottom quarter of a poorly educated college population. For the most part, they are ill-equipped to handle the rigors of mathematics and science. In addition, they are generally protected by tenure and thus they have no incentive to improve. The only teachers who could benefit from in-service training is that rapidly dwindling number of older, capable individuals who received a thorough education years ago.

Teacher scholarship programs are also unlikely to remedy the present problems in math and science education as long as they seek candidates from the pool of current high school graduates. Programs, such as that at the Harvard Graduate School of Education, in which corporate retirees are being trained to become teachers of mathematics and science, offer the most realistic way to lure this talent into the classroom. Older men have met the challenge of the marketplace. Personal ambition has been fulfilled. Many are now willing and available to serve one of the higher aims of mankind--the training of its youth.

Business/industry/school partnerships merit some exploration. But education cannot serve only the marketplace. It has a far wider function. Moreover, assuming that the principal obstacle to providing adequate science education is a shortage of hardware in the public schools is a trap that must be avoided. Mental discipline and subject content are the missing links. Witness the fact that school closets are packed with unused teaching machines and other relics of the "classroom technological revolution" of the 1960s. The problem is not lack of machines or lack of money; the problem is lack of teachers with mental discipline, professionalism, subject knowledge, and personal commitment to the highest goals of education.

RECOMMENDATIONS

What needs to be done is:

1. Redefine teacher certification requirements. Existing certification requirements bar competent individuals from entering the teaching profession and protect those already in the system. Excellence in teaching requires, minimally, (a) a liberal arts education and (where applicable) expertise in a specific subject area; (b) a course in human development (so that the aspiring teacher will be knowledgeable of the sequential development of children's logical reasoning); and (c) classroom apprenticeships to acquaint the candidate with children and with classroom procedures.

2. Accredit teachers through rigorous testing of general intelligence and knowledge in specific subject matter. These

are the primary determinants of an individual's ability to impart knowledge. Doctors must pass stringent state medical licensing boards; lawyers must pass stringent state bar exams; teachers should have to pass stringent state teacher exams to determine their fitness to teach.

3. Base salaries on performance and need. High quality learning comes from high quality teaching. And high quality teachers ought to be paid what they are worth. Seniority should not be the measure by which salary increments are received; performance should. In addition, with certification requirements redefined and accreditation standards firmly in place, there should be salary differentials to offset the serious shortage of teachers in mathematics and science.

4. Withdraw federal mandates. Mandates have diluted the curriculum by catering to special interests, to the detriment of the whole. Upgrading mathematics and science education will have far less impact on student performance if the rest of the curriculum is mandated by present day social legislation; for, the by-products of a sound education in mathematics and science (discrimination, judgment, accurate labeling, the ability to weigh competing claims based on their relative merits) are at fundamental odds with the ideological underpinnings of this legislation (that all points of view, cultures, and contributions have equal merit and are not to be critically examined).

5. Limit federal funding of education. Federal monies mean federal control, and during the past fifteen years, the federal government has clearly demonstrated its inability to work in education for the welfare of the whole. It has relinquished its control of education to social reformers whose "reforms" have forced upon our schools a false and destructive ideology.

Education is a state and local matter and should be returned to them. Local regulations of education may, in some cases, warrant criticism, yet it is better that an isolated school system here and there go astray than that an entire nation of school systems do so.

To this end, the federal government should aggregate its discretionary programs in education into block grants and allocate these funds to the states. This would diminish federal involvement and allow states and localities the time to accumulate tax provided funds to continue the program, if they desire.

The proper role of the federal government in education has been identified by the Reagan Administration: education is in essence a local, private matter and can be most effectively handled at those levels. Quite properly, the Administration would have the federal government focus its limited resources on defining and encouraging excellence, (through exemplary private sector research projects), making available the most up-to-date and well-proven methods of its attainment, and rewarding people and programs that exemplify excellence in education with presidential excellence awards.

CONCLUSION

Education reflects the values and priorities of society. Over the past twenty years, those values and priorities in the United States have been determined in large part by federal legislation and judicial mandates. These fiats have established and nourished programs and attitudes antithetical to the competencies and skills which are fundamental to mathematics and science.

Massive federal funding to implement the mandated programs and policies has fed the malady that now afflicts education and its component parts. Paradoxically, those who have demanded and continue to demand federal programs and funding are now prominent in the ranks of those who react with dismay at the results and, panic stricken, seek to curtail what they continue to promote.

It must be remembered that the ultimate function of education is to make man all that he is capable of being. To attain this, an education program must provide the finest leadership, emphasize excellence, profess and pursue the highest of values, and foster perceptual clarity and intellectual acumen in those it seeks to serve. It is all too evident that the expanding role of the federal government has eroded, rather than strengthened, these principles. And there is little reason to believe that the solution proferred by Congress for the deficiencies in mathematics and science teaching--more federal involvement--will move the nation's schools once again in the proper direction.

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